AMENDMENT

The Office Action makes numerous objections to the specification and claims. For clarity, a substitute specification is provided. A clean copy and a copy including revision markings are provided. No new matter has been added.

REMARKS

Drawing Objection

The Figures were objected to because the specification refers to 80 as a process controller and a tool controller. The specification and Figure 2 were amended to consistently refer to a process controller 80. A revised Figure 2 changing tool controller to process controller is included herewith. Figure 2 was also amended to be consistent with claim 1 as amended.

35 U.S.C. § 112 Specification Objections

The Office Action asserts that the language relating to a partial and full qualification process is unclear. Applicants assert that the cited passage is clear to one of ordinary skill in the art. A full qualification process would determine values for X parameters for initializing the control model. A reduced qualification process, in contrast, only determines a subset of the X parameters. For example, a cleaning process may or pad replacement may only affect certain of the parameters employed by the control model. Only those parameters that are affected need be determined. The reduced qualification process may thus require less test wafers or less measurements on the test wafers than a full qualification procedure. Again these distinctions are well known by those of ordinary skill in the art. Applicants respectfully request this objection be withdrawn.

The Office Action objects to the specification for failing to provide antecedent basis for claims 4, 7-10, 12-16, 18-20, 23-27, 32-34, 35, and 37-45. Citations to the specification refer to the originally filed specification.

Claim 4 was corrected to recite a polishing tool as opposed to a deposition tool. Regarding claims 4, 34 and 37, the Office Action asserts that estimating a material removal rate as the control variable is not supported by the specification. Regarding claims 7 and 18, the Office Action asserts that processing a test wafer to determine a blanket wafer removal rate is not supported by the specification To the contrary, this claim language is supported by the original specification on page 10, lines 3-15. Applicants respectfully request these objections be withdrawn.

Regarding claims 8 and 38, the Office Action asserts that determining an overlay characteristic for a photolithography stepper is not supported by the specification. Regarding claims 16 and 27, and 45, the Office Action asserts that a tool event notification based on a red-blue calibration for a stepper is not supported by the specification. The specification at page 11, lines 3-8 provides antecedent basis for this claim language. Applicants respectfully request these objections be withdrawn.

Regarding claims 9, 10, 20, 32, 33, 39, and 40, the Office Action asserts that using etch rate of an etch tool or a deposition rate for a deposition tool as control variables and estimating or determining values for these parameters is not supported by the specification. Claim 40 was amended to correct an errant reference to a polishing tool. The specification at page 10, line 19 through page 11, line 2 provides antecedent basis for this claim language. Applicants respectfully request these objections be withdrawn.

Regarding claims 12-15, 23-26, and 41-44, the Office Action asserts that tool event notifications based on deposition and etch chamber cleaning and polishing pad replacement and conditioning are not supported by the specification. The specification at page 9, lines 4-20, and page 11, lines 12-14 provides antecedent basis for this claim language. Applicants respectfully request these objections be withdrawn.

Regarding claim 35, the Office Action asserts that contacting the process control server to schedule a qualification procedure is not supported by the specification. The specification at page 10, lines 10-13, and page 11, lines 5-8 provides antecedent basis for this claim language. Applicants respectfully request this objection be withdrawn.

35 U.S.C. § 112 Claim Objections

Claims 3-5, 7-10, 12-16, 18-21, 32-34, and 36-40 have been objected to for having various informalities.

In claims 3-5, and 32-34, the Office Action suggests that "estimating the control" should be changed to "said [process] controller estimating the control." However, the method element in parent claim 2 is "estimating a control variable," which has not been attributed to the process controller. The dependent claims cited by the Office Action modify the method element of claim 2, and are this worded correctly. Claim 32-34 do not include similar language. The "estimated control variable" recited in claims 32-34 corresponds to the "estimated control variable" in parent claim 31. It is not necessary to repeat the recitation of the process controller estimating the control variable as it is already present in claim 31. Applicants respectfully request the rejection of these claims be withdrawn.

Likewise, "performing the qualification" in claims 7-10 and 18-21 properly recite the method element of the parent claim and are not attributed to the process controller. Claims 37-40 were amended to attribute the qualification procedure to the tool and the determining of the control variable value to the process controller. Claim 36 was amended to be consistent with claims 37-40. Applicants respectfully request the rejection of these claims be withdrawn.

The language "receiving the tool event" in claims 12-16 and 23-27 properly recite the method element of the parent claim and are not attributed to the process controller. Applicants respectfully request the rejection of these claims be withdrawn.

Prior Art Rejections

Claims 1, 6, 17 and 28 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Lantz. Claim 29 stands rejected under 35 U.S.C. § 103(a) as being obvious over Lantz. Claims 1, 6, 11, 17, 22, and 28-30 stand rejected under 35 U.S.C. § 103(a) as being obvious over Barnett in view of Bunkofske. Claims 2 and 31 stand rejected under 35 U.S.C. § 103(a) as being obvious over Lantz or Barnett in view of Bunkofske. Claims 35 and 36 stand rejected under 35 U.S.C. § 103(a) as being obvious over Lantz or Barnett in view of Bunkofske and Nulman. Claims 3-5, 7-10, 12-16, 18-21, 23-27, 32-24 and 37-45 stand rejected under 35 U.S.C. § 103(a) as being obvious over the article by Michael Quirk.

Independent claims 1, 17, and 28, include the general feature of initializing a control model employed by a process controller for controlling a process tool in response to receiving a tool event notification. Claim 17 includes the additional feature of performing a qualification procedure responsive to the tool event notification for determining a control variable for initializing the control model.

The Office Action asserts that Lantz and/or the combination of Barnett and Bunkofske teach these features. Both Lantz and Barnett teach loading an operating recipe for the tool based on identification information associated with a particular lot. Lantz and Barnett are directed to recipe management, not process control of the tool using a control model. Loading an operating recipe does not equate to employing a control model and initializing the control model in response to receiving a tool event notification. A control model is used to modify the base operating recipe of the tool. Lantz and Barnett only load a default operating recipe. For example, a feedback or feedforward control action may be generated for the tool based on target and current state information for the tool in accordance with the control model. If metrology data indicates that a tool is missing its target, the control model is used in conjunction with the metrology data and target information to adjust the tool recipe to attempt to reduce the variation from target.

The Office Action also asserts that each processing run comprises a tool event. However, this construction is contrary to Applicants teachings. If a control model were to be initialized for every processing run, the process controller would not be able to control the tool.

The Office Action asserts that determining if a tool can perform a process is a qualification procedure. This construction is contrary to the usage of the term in the semiconductor fabrication art. A qualification procedure is used to establish baseline operating information about a process tool, such as deposition rate, etch rate, polishing rate, *etc*. Merely determining if a tool is capable of performing a process does not establish any information regarding the tool state and therefore cannot be a qualification procedure.

Bunkofske, Nulman, and Quirk fail to correct the defects identified above with Lantz. Because the cited art fails to teach or suggest initializing a control model employed by a process controller for controlling a process tool in response to receiving a tool event notification, claims 1, 17, 28, and all claims depending therefrom, are allowable. Applicants respectfully request the rejection of these claims be withdrawn.

In view of the remarks set forth herein, the application is believed to be in condition for allowance and notice to that effect is solicited. Nonetheless, should any issues remain that might be subject to resolution through a telephonic interview, the examiner is requested to contact the undersigned attorney with any questions, comments or suggestions relating to the referenced patent application.

Respectfully submitted,

23720
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for

METHOD AND APPARATUS FOR INITIALIZING [TOOL] PROCESS CONTROLLERS BASED ON TOOL EVENT DATA

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Signature

METHOD AND APPARATUS FOR INITIALIZING [TOOL] PROCESS CONTROLLERS BASED ON TOOL EVENT DATA

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates generally to semiconductor device manufacturing and, more particularly, to a method and apparatus for initializing [tool] process controllers based on tool event data.

2. DESCRIPTION OF THE RELATED ART

There is a constant drive within the semiconductor industry to increase the quality, reliability and throughput of integrated circuit devices, *e.g.*, microprocessors, memory devices, and the like. This drive is fueled by consumer demands for higher quality computers and electronic devices that operate more reliably. These demands have resulted in a continual improvement in the manufacture of semiconductor devices, *e.g.*, transistors, as well as in the manufacture of integrated circuit devices incorporating such transistors. Additionally, reducing the defects in the manufacture of the components of a typical transistor also lowers the overall cost per transistor as well as the cost of integrated circuit devices incorporating such transistors.

Generally, a set of processing steps is performed on a lot of wafers using a variety of processing tools, including photolithography steppers, etch tools, deposition tools, polishing tools, rapid thermal processing tools, implantation tools, *etc.* The technologies underlying semiconductor processing tools have attracted increased attention over the last several years, resulting in substantial refinements. However, despite the advances made in this area, many of the processing tools that are currently commercially available suffer certain deficiencies.

In particular, such tools often lack advanced process data monitoring capabilities, such as the ability to provide historical parametric data in a user-friendly format, as well as event logging, real-time graphical display of both current processing parameters and the processing parameters of the entire run, and remote, *i.e.*, local site and worldwide, monitoring. These deficiencies can engender nonoptimal control of critical processing parameters, such as throughput, accuracy, stability and repeatability, processing temperatures, mechanical tool parameters, and the like. This variability manifests itself as within-run disparities, run-to-run disparities and tool-to-tool disparities that can propagate into deviations in product quality and performance, whereas an ideal monitoring and diagnostics system for such tools would provide a means of monitoring this variability, as well as providing means for optimizing control of critical parameters.

One technique for improving the operation of semiconductor processing line includes using a factory wide control system to automatically control the operation of the various processing tools. The manufacturing tools communicate with a manufacturing framework or a network of processing modules. Each manufacturing tool is generally connected to an equipment interface. The equipment interface is connected to a machine interface which facilitates communications between the manufacturing tool and the manufacturing framework. The machine interface can generally be part of an advanced process control (APC) system. The APC system initiates a control script based upon a manufacturing model, which can be a software program that automatically retrieves the data needed to execute a manufacturing process. Often, semiconductor devices are staged through multiple manufacturing tools for multiple processes, generating data relating to the quality of the processed semiconductor devices.

Various tools in the processing line are controlled in accordance with performance models to reduce processing variation. Commonly controlled tools include photolithography steppers, polishing tools, etching tools, and deposition tools. Pre-processing and/or post-processing metrology data is supplied to process controllers for the tools. Operating recipe parameters, such as processing time, are calculated by the process controllers based on the performance model and the metrology information to attempt to achieve post-polishing results as close to a target value as possible. Reducing variation in this manner leads to increased throughput, reduced cost, higher device performance, *etc.*, all of which equate to increased profitability.

Commonly, a processing tool undergoes periodic preventative maintenance procedures or calibrations to keep the tool in optimum operating condition. For example, polishing tools include polishing pads that are periodically conditioned or replaced. Etch tools and deposition tools are periodically cleaned using both *in situ* cleans or complete disassembly cleans. Steppers are periodically calibrated to maintain alignment accuracy and exposure dose consistency.

The discrete maintenance activities, collectively referred to as tool events, often cause step changes in the processing characteristics of the tool. The control routines implemented by an automated process controller on the tool may experience problems as a result of these changes. For example, a process controller for a chemical mechanical polishing (CMP) tool uses the blanket wafer removal rate of a polishing pad for modeling the performance (*e.g.*, polishing rate) of the polishing tool. After a pad is conditioned or replace, the blanket wafer removal rate changes, thus disrupting the model. If the process controller attempts to control the CMP tool under the new processing characteristics, the polishing process may be poorly controlled or may even result in an unstable control algorithm. These control problems may

result in increased variation or even defective wafers. Over time, the process controller may adjust its performance model based on post-processing metrology feedback, however, the wafers produced in the interim may be suspect. In some situations, the process controller might never be able to stabilize the process. Similar control problems may be experienced by process controllers on other tools.

The present invention is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

SUMMARY OF THE INVENTION

One aspect of the present invention is seen in a method for initializing [tool] process controllers based on tool event data. The method includes providing a tool having a [tool] process controller adapted to control an operating recipe of the tool; receiving a tool event notification; and initializing the [tool] process controller in response to receiving the tool event notification.

Another aspect of the present invention is seen in a manufacturing system including a tool and a [tool] process controller. The tool is adapted to process wafers in accordance with an operating recipe. The [tool] process controller is adapted to control the operating recipe in accordance with a control algorithm. The [tool] process controller is further adapted to receive a tool event notification and initialize the control algorithm in response to receiving the tool event notification.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Figure 1 is a simplified block diagram of a manufacturing system in accordance with one illustrative embodiment of the present invention; and

Figure 2 is a simplified flow diagram of a method for initializing [tool] process controllers based on tool event data in accordance with another embodiment of the present invention.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

Referring to Figure 1, a simplified block diagram of an illustrative manufacturing system 10 is provided. A network 20 interconnects various components of the manufacturing system, allowing them to exchange information. The illustrative manufacturing system 10

includes a plurality of tools 30, each being coupled to a computer 40 for interfacing with the network 20. A process control server 50 directs the high level operation of the manufacturing system 10 by directing the process flow of the manufacturing system 10. The process control server 50 monitors the status of the various entities in the manufacturing system, including the tools 30. A database server 60 is provided for storing data related to the status of the various entities and articles of manufacture (*e.g.*, wafers) in the process flow. The database server 60 may store information in one or more data stores 70. The data may include pre-process and post-process metrology data, tool states, process flow activities (*e.g.*, scheduled maintenance events, processing routes for lots of wafers), *etc.* The distribution of the processing and data storage functions amongst the different computers 40, 50, 60 is generally conducted to provide independence and a central information store. Of course, more or less computers may be used.

An exemplary information exchange and process control framework suitable for use in the manufacturing system 10 is an Advanced Process Control (APC) framework, such as may be implemented using the Catalyst system offered by KLA-Tencor, Inc. The Catalyst system uses Semiconductor Equipment and Materials International (SEMI) Computer Integrated Manufacturing (CIM) Framework compliant system technologies and is based the Advanced Process Control (APC) Framework. CIM (SEMI E81-0699 - Provisional Specification for CIM Framework Domain Architecture) and APC (SEMI E93-0999 - Provisional Specification for CIM Framework Advanced Process Control Component) specifications are publicly available from SEMI.

Portions of the invention and corresponding detailed description are presented in terms of software, or algorithms and symbolic representations of operations on data bits within a computer memory. These descriptions and representations are the ones by which

those of ordinary skill in the art effectively convey the substance of their work to others of ordinary skill in the art. An algorithm, as the term is used here, and as it is used generally, is conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of optical, electrical, or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise, or as is apparent from the discussion, terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical, electronic quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

Some of the tools 30 include process controllers 80 that are adapted to automatically control the operating recipes of their respective tools 30. For example, if the tool 30 is a CMP tool, the process controller 80 may receive pre-polish thickness measurements (*e.g.*, thickness of high features, thickness of low features) and predict a polishing time required to achieve a post-polish target thickness. The process controller 80 may use a performance model of the tool 30 to generate its prediction. In the case where the tool 30 is an etch tool, the process controller 80 may model the etching performance of the tool 30 based on pre-etch

and/or post-etch thickness measurements. Using the model, the process controller 80 may determine operating recipe parameters such as etch time, plasma power, temperature, pressure, reactant gas concentrations, *etc.* to reduce post-etch thickness variations. Other control scenarios are possible with other types of processing tools.

Various tool events, such as maintenance procedures (*e.g.*, chamber cleaning, polishing pad conditioning, consumable item replacement), calibrations, *etc.*, may affect the operating characteristics of the tool 30, thus causing difficulty for the process controller 80 in maintaining the stability of its control algorithm. In some instances, it may take the process controller 80 numerous iterations to account for the operating characteristic change due to the tool event. Product processed during the interim may be defective. In other cases, it may be entirely impossible for the process controller 80 to handle the operating characteristic change.

The process controllers 80 are notified of tool events that have the potential for affecting the operating characteristics of their associated tools 30. Such notification may be conducted automatically or manually. For example, the process control server 50 may schedule maintenance activities and notify the process controllers 80 upon completion of the activities. Alternatively, the process controllers 80 may be capable of detecting certain tool events independently. For example, the process control 80 may detect the performance of a conditioning or cleaning recipe on the tool 30. In still another embodiment, a tool operator may signal the process controller 80 of the tool event through an operator interface 90 operating on the computer 40 (*i.e.*, an operator may input the data after the scheduled maintenance on the tool has been performed).

In response to receiving a tool event notification, the process controller 80 may take a variety of actions to limit the likelihood of defective product processing. The specific actions may vary depending on the nature of the tool event and the control abilities of the process

controller 80. Collectively, the actions taken in response to the tool event notification are referred to as initializing the process controller 80 based on the new operating characteristics of the tool 30.

In a first embodiment, the process controller 80 is adapted to control the tool 30 using a model or set of equations that include a processing characteristic of the tool 30. For example, in the control of a CMP tool, the blanket wafer removal rate (*i.e.*, the rate at which the CMP tool removes material on a test wafer coated with a blanket layer of material) is used in a control model for determining the removal rate for the tool 30 over time. The largest impact on the removal rate is seen when new polishing pads are installed on the CMP tool. Smaller, yet noticeable, removal rate changes are seen when the polishing pads are conditioned. In response to receiving the tool event notification, the process controller 80 may communicate with the process control server 50 or a tool operator to force the processing of one or more test wafers in the tool 30 to determine a new blanket wafer removal rate. The qualification process may be reduced in scope compared to a full scale tool qualification procedure. Using the new blanket wafer removal rate, the process controller 80 may initialize its control model for subsequent processing runs.

In a second embodiment, the process controller 80 may be capable of estimating the effect of the new operating characteristics of the tool 30 on its control algorithm performance. For example, historical data may allow the process controller 80 to generate an approximate value for a control variable used in its performance model. For example, the effect on etch rate or deposition rate following an *in situ* cleaning of the chamber operation may be predictable. The process controller 80 then uses an approximate processing rate to initialize its control model for subsequent processing runs. The approximate value can be refined using feedback information provided by post-process metrology for the processing runs

subsequent to the cleaning. Alternatively, as in the first example, the process controller 80 may force one or more test or qualification wafers to ensure process control stability.

In a third embodiment, the effect of the tool event may be so unpredictable that an estimate or limited qualification run is not suitable for initializing the process controller. For example, following a red-blue correlation in a stepper the overlay characteristics may be markedly different than before the procedure. In such a case, the process controller 80 may communicate with the [work] <u>process</u> control server 50 or a tool operator to force a complete re-qualification of the tool 30 prior to allowing subsequent production.

Turning now to Figure 2, a simplified flow diagram of a method for initializing [tool] <u>process</u> controllers based on tool event data is provided. In block 200, a tool 30 having a [tool] <u>process</u> controller 80 adapted to control an operating recipe of the tool is provided. In block 210, a tool event notification is received. The tool event notification may be associated with the performance of a preventative maintenance procedure (*e.g.*, chamber cleaning, polishing pad conditioning, consumable item replacement), calibration, *etc.* In block 220, the [tool] <u>process</u> controller 80 is initialized in response to receiving the tool event notification. Initializing the [tool] <u>process</u> controller 80 may include estimating a control variable value associated with the process performed by the tool 30. Alternatively, initializing the [tool] <u>process</u> controller 80 may include performing a qualification procedure to determine the control variable value. The [tool] <u>process</u> controller 80 may interface with a process control server 50 responsible for directing the high level operation of the manufacturing system 10 to schedule the qualification procedure.

Automatically initializing the process controller 80 based on tool event notifications, as described above, has numerous advantages. Process deviations and control instabilities caused by changes in the operating characteristics of the tool 30 after the tool event may be

addressed. The process controller 80 may initialize its control model using an estimated operating characteristic value. Alternatively, the process controller 80 may force a limited or full qualification process to provide inputs for initializing its control model. Also, tool operators and the manufacturing system 10 may be notified of actions required after tool events, thus reducing the likelihood of an operator inadvertently failing to perform qualification procedures.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

WHAT IS CLAIMED:

1. (Amended) A method for initializing [tool] process controllers based on tool event data, comprising:

providing a tool having a [tool] process controller adapted to employ a control model to control an operating recipe of the tool;

receiving a tool event notification; and

initializing the control model [tool controller] in response to receiving the tool event notification.

2. (Amended) The method of claim 1, wherein initializing the [tool controller] control model comprises:

estimating a control variable value; and

initializing [a] the control model [algorithm of the tool controller] based on the estimated control variable value.

3. The method of claim 2, wherein the tool comprises an etch tool adapted to etch features on a semiconductor wafer, and estimating the control variable value includes estimating an etch rate.

4. (Amended) The method of claim 2, wherein the tool comprises a [deposition] polishing tool adapted to planarize a semiconductor wafer, and estimating the control variable value includes estimating a material removal rate.

5. The method of claim 2, wherein the tool comprises a deposition tool adapted to form a layer on a semiconductor wafer, and estimating the control variable value includes estimating a deposition rate.

6. (Amended) The method of claim 1, further comprising:

performing a qualification procedure on the tool in response to receiving the tool event notification to determine a control variable value; and

initializing [a] <u>the</u> control <u>model</u> [algorithm of the tool controller] based on the control variable value.

7. The method of claim 6, wherein the tool comprises a polishing tool adapted to planarize a semiconductor wafer, and performing the qualification procedure comprises processing a test wafer in the polishing tool to determine a blanket wafer removal rate.

8. The method of claim 6, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, and performing the qualification procedure comprises processing a test wafer in the photolithography stepper to determine an overlay characteristic of the photolithography stepper.

9. The method of claim 6, wherein the tool comprises a deposition tool adapted to form a layer on a semiconductor wafer, and performing the qualification procedure comprises depositing the process layer on a test wafer in the deposition tool to determine a deposition rate.

10. The method of claim 6, wherein the tool comprises an etch tool adapted to etch features on a semiconductor wafer, and performing the qualification procedure comprises etching a test wafer in the etch tool to determine an etch rate.

11. The method of claim 1, wherein receiving the tool event notification comprises receiving a notification of at least one of a tool calibration and a tool preventative maintenance activity.

12. The method of claim 1, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when the polishing pad is replaced.

13. The method of claim 1, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when the polishing pad is conditioned.

14. The method of claim 1, wherein the tool comprises an etch tool having a chamber, and receiving the tool event notification comprises receiving a notification when the chamber is cleaned.

15. The method of claim 1, wherein the tool comprises a deposition tool having a chamber, and receiving the tool event notification comprises receiving a notification when the chamber is cleaned.

16. The method of claim 1, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when a red-blue calibration is performed on the photolithography stepper.

17. (Amended) A method for initializing [tool] <u>process</u> controllers based on tool event data, comprising:

providing a tool having a [tool] <u>process</u> controller adapted to <u>employ a control model to</u> control an operating recipe of the tool;

receiving a tool event notification;

performing a qualification procedure on the tool in response to receiving the tool event notification to determine a control variable; and

initializing the [tool controller] <u>control model</u> based on the control variable.

18. The method of claim 17, wherein the tool comprises a polishing tool adapted to planarize a semiconductor wafer, and performing the qualification procedure comprises processing a test wafer in the polishing tool to determine a blanket wafer removal rate.

19. The method of claim 17, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, and performing the qualification procedure comprises processing a test wafer in the photolithography stepper to determine an overlay characteristic of the photolithography stepper.

20. The method of claim 17, wherein the tool comprises a deposition tool adapted to form a layer on a semiconductor wafer, and performing the qualification procedure

comprises depositing the process layer on a test wafer in the deposition tool to determine a deposition rate.

21. The method of claim 17, wherein the tool comprises an etch tool adapted to etch features on a semiconductor wafer, and performing the qualification procedure comprises etching a test wafer in the etch tool to determine an etch rate.

22. The method of claim 17, wherein receiving the tool event notification comprises receiving a notification of at least one of a tool calibration and a tool preventative maintenance activity.

23. The method of claim 17, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when the polishing pad is replaced.

24. The method of claim 17, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when the polishing pad is conditioned.

25. The method of claim 17, wherein the tool comprises an etch tool having a chamber, and receiving the tool event notification comprises receiving a notification when the chamber is cleaned.

26. The method of claim 17, wherein the tool comprises a deposition tool having a chamber, and receiving the tool event notification comprises receiving a notification when the chamber is cleaned.

27. The method of claim 17, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, and receiving the tool event notification comprises receiving a notification when a red-blue calibration is performed on the photolithography stepper.

28. (Amended) A manufacturing system, comprising:

a tool adapted to process wafers in accordance with an operating recipe; and

a [tool] <u>process</u> controller adapted to control the operating recipe in accordance with a control <u>model</u> [algorithm], wherein the [tool] <u>process</u> controller is further adapted to receive a tool event notification and initialize the control [algorithm] <u>model</u> in response to receiving the tool event notification.

29. (Amended) The manufacturing system of claim 28, further comprising a process control server adapted to send the tool event notification to the [tool] <u>process</u> controller.

30. The manufacturing system of claim 28, wherein the tool event notification comprises a notification of at least one of a tool calibration and a tool preventative maintenance activity.

31. (Amended) The manufacturing system of claim 28, wherein the [tool] process controller is adapted to estimate a control variable value and initialize the control model [algorithm] based on the estimated control variable value.

32. The manufacturing system of claim 31, wherein the tool comprises an etch tool adapted to etch features on a semiconductor wafer, and the estimated control variable value comprises an etch rate.

33. The manufacturing system of claim 31, wherein the tool comprises a deposition tool adapted to form a layer on a semiconductor wafer, and the estimated control variable value comprises a deposition rate.

34. (Amended) The manufacturing system of claim 31, wherein the tool comprises a polishing tool adapted to planarize a semiconductor wafer, and the estimated control variable value comprises a [polishing] material removal rate.

35. (Amended) The manufacturing system of claim 29, wherein the [tool] process controller is adapted to contact the process control server to schedule a qualification procedure on the tool in response to receiving the tool event notification.

36. (Amended) The manufacturing system of claim 35, wherein the tool is adapted to perform the qualification procedure, and the process controller is configured to determine a control variable value based on the qualification procedure.

37. (Amended) The manufacturing system of claim 36, wherein the tool comprises a polishing tool adapted to planarize a semiconductor wafer, [and] the qualification procedure comprises processing a test wafer in the polishing tool, and the process controller is configured to determine a blanket wafer removal rate as the control variable value.

38. (Amended) The manufacturing system of claim 36, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, [and] the qualification procedure comprises processing a test wafer in the photolithography stepper, and the process controller is configured to determine an overlay characteristic of the photolithography stepper.

39. (Amended) The manufacturing system of claim 36, wherein the tool comprises an etch tool adapted to etch features on a semiconductor wafer, [and] the qualification procedure comprises etching a test wafer in the polishing tool, and the process controller is configured to determine an etch rate as the control variable value.

40. (Amended) The manufacturing system of claim 36, wherein the tool comprises a deposition tool adapted to form a process layer on a semiconductor wafer, [and] the qualification procedure comprises forming the process layer on a test wafer in the [polishing] deposition tool, and the process controller is configured to determine a deposition rate as the control variable value.

41. The manufacturing system of claim 28, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and the tool event notification comprises a notification that the polishing pad has been replaced.

42. The manufacturing system of claim 28, wherein the tool comprises a polishing tool having at least one polishing pad adapted to planarize a semiconductor wafer, and the tool event notification comprises a notification that the polishing pad has been conditioned.

43. The manufacturing system of claim 28, wherein the tool comprises an etch tool having a chamber, and the tool event notification comprises a notification that the chamber has been cleaned.

44. The manufacturing system of claim 28, wherein the tool comprises a deposition tool having a chamber, and the tool event notification comprises a notification that the chamber has been cleaned.

45. The method of claim 28, wherein the tool comprises a photolithography stepper adapted to expose a photoresist layer on a semiconductor wafer, and the tool event notification comprises a notification that a red-blue calibration has been performed on the photolithography stepper.

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ABSTRACT OF THE DISCLOSURE

A method for initializing [tool] process controllers based on tool event data includes providing a tool having a [tool] process controller adapted to employ a control model to control an operating recipe of the tool; receiving a tool event notification; and initializing the [tool controller] control model in response to receiving the tool event notification. A manufacturing system includes a tool and a [tool] process controller. The tool is adapted to process wafers in accordance with an operating recipe. The [tool] process controller is adapted to employ a control model to control the operating recipe in accordance with a control algorithm. The [tool] process controller is further adapted to receive a tool event notification and initialize the control [algorithm] model in response to receiving the tool event notification.